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(54) **LOCAL CACHING DEVICE, SYSTEM AND METHOD FOR PROVIDING CONTENT CACHING SERVICE**

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G06F 17/30 (2006.01)
G06F 12/08 (2006.01)
H04L 29/08 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 17/30982*** (2013.01); ***G06F 12/0875*** (2013.01); ***G06F 17/30902*** (2013.01); ***H04L 67/2842*** (2013.01); ***H04L 67/2852*** (2013.01)

(58) **Field of Classification Search**
CPC G06F 12/0875; G06F 12/084; G06F 17/30982; G06F 17/30902; H04L 67/2852; H04L 67/2842; H04L 67/1097
See application file for complete search history.

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(57) **ABSTRACT**

The present disclosure relates to a local caching device, system and method for providing a content caching service. The local caching device receives, from a content provider, at least one part of content requested by a user terminal and then, based on the received part of the requested content, determines whether the requested content is stored in a storage unit. If the requested content is stored, the local caching device registers flow information of the requested content in the storage unit. When content having the same flow information as the registered flow information is requested, the local caching device determines based on content address information whether the requested content is stored.

15 Claims, 6 Drawing Sheets

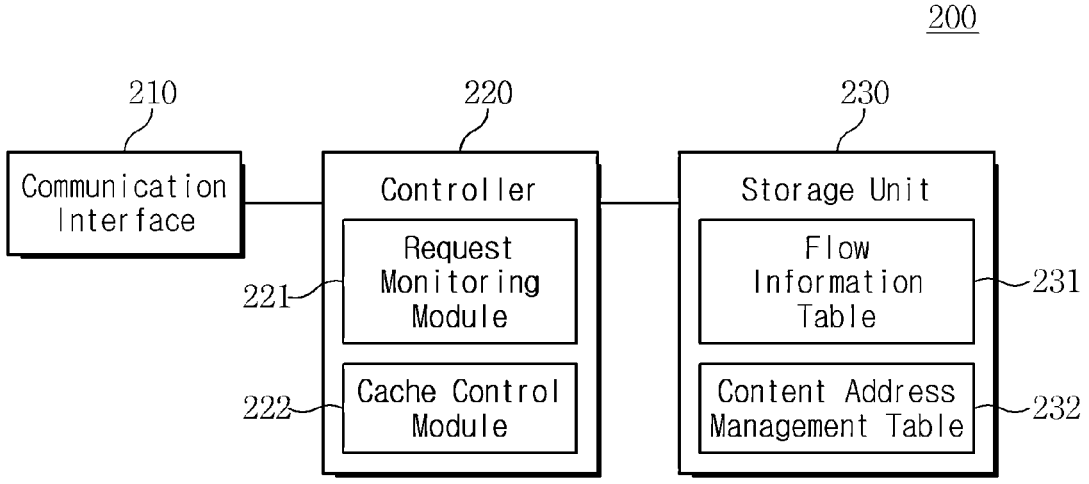


FIG. 1

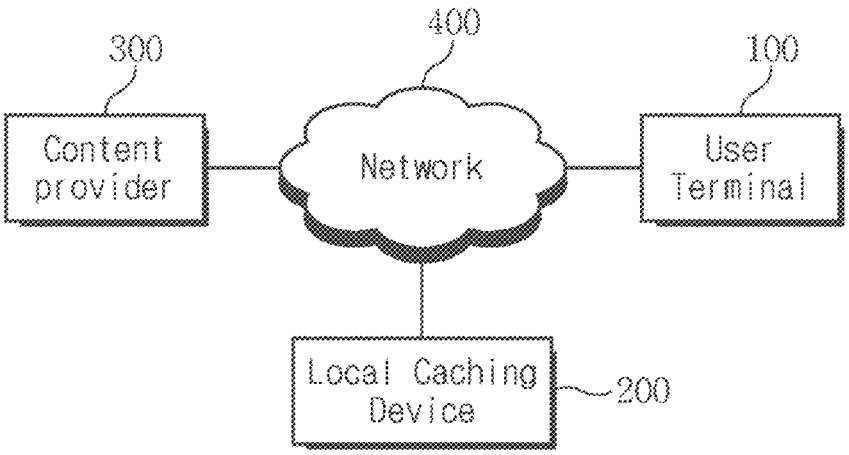

300
400
100
Content provider
Network
User Terminal
Local Caching Device
200

FIG. 2

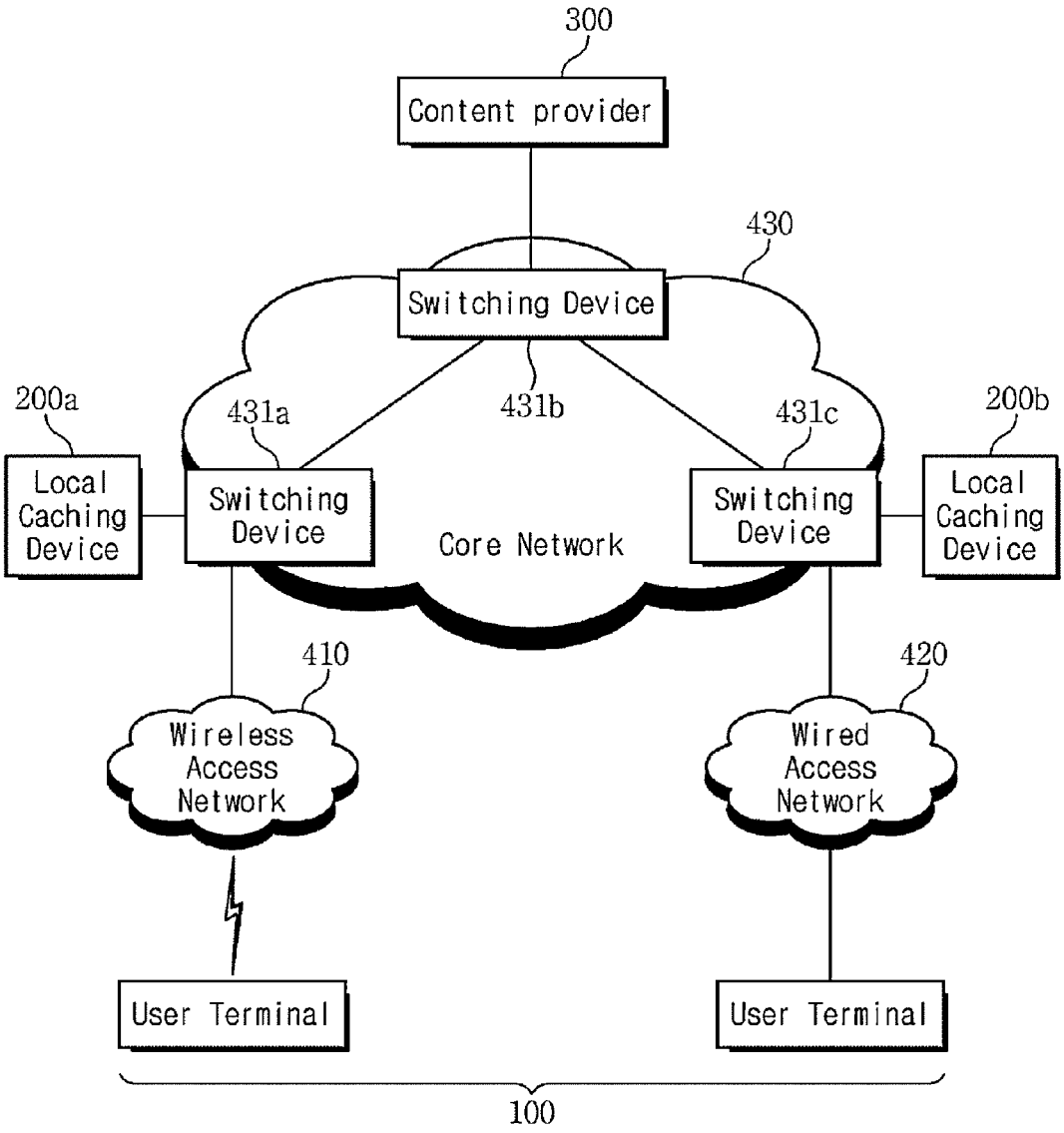

300
Content provider
430
Switching Device
200a
431a
431b
431c
200b
Local Caching Device
Switching Device
Core Network
Switching Device
Local Caching Device
410
420
Wireless Access Network
Wired Access Network
User Terminal
User Terminal
100

FIG. 3

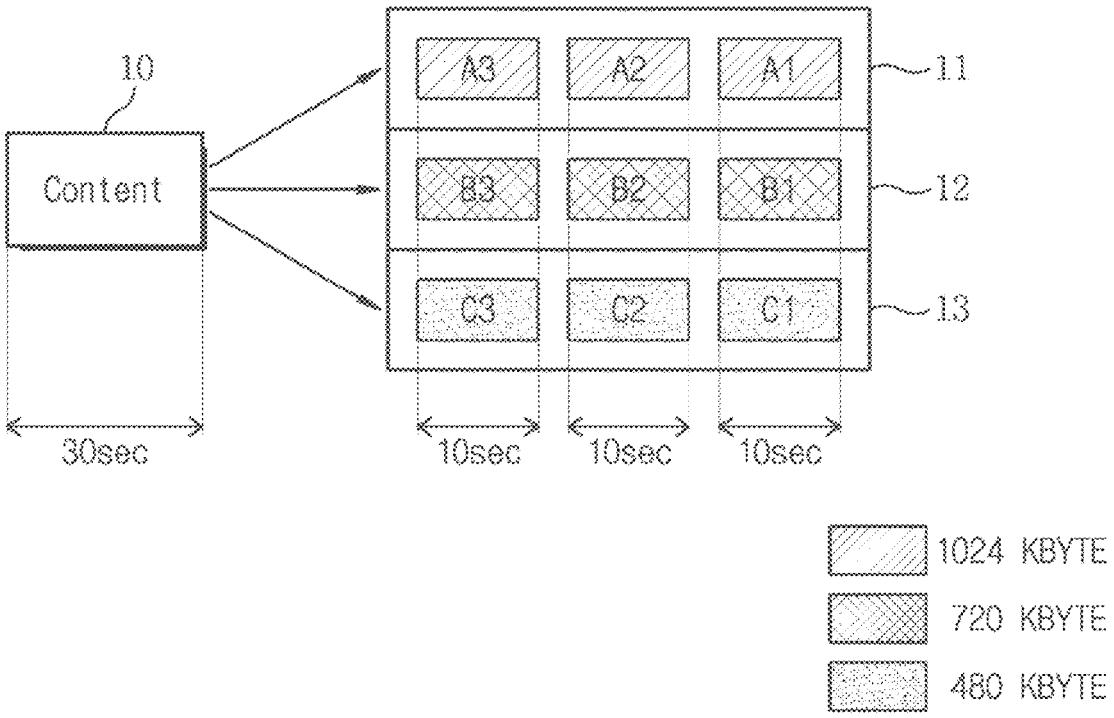

10
Content
A3
A2
A1
B3
B2
B1
C3
C2
C1
11
12
13
30sec
10sec
10sec
10sec
1024 KBYTE
720 KBYTE
480 KBYTE

FIG. 4

(a)

Source Address Information	Destination Address Information
Server2_IP	UE_IP,UE_Port
Server1_IP	UE_IP,UE_Port
⋮	⋮

(b)

Content Identification Information	Content Address Information
Content-A	www.abc.com/his_300k_01.ts
Content-B	www.abc.com/his_300k_02.ts
Content-C	www.abc.com/his_500k_03.ts
⋮	⋮

FIG. 5

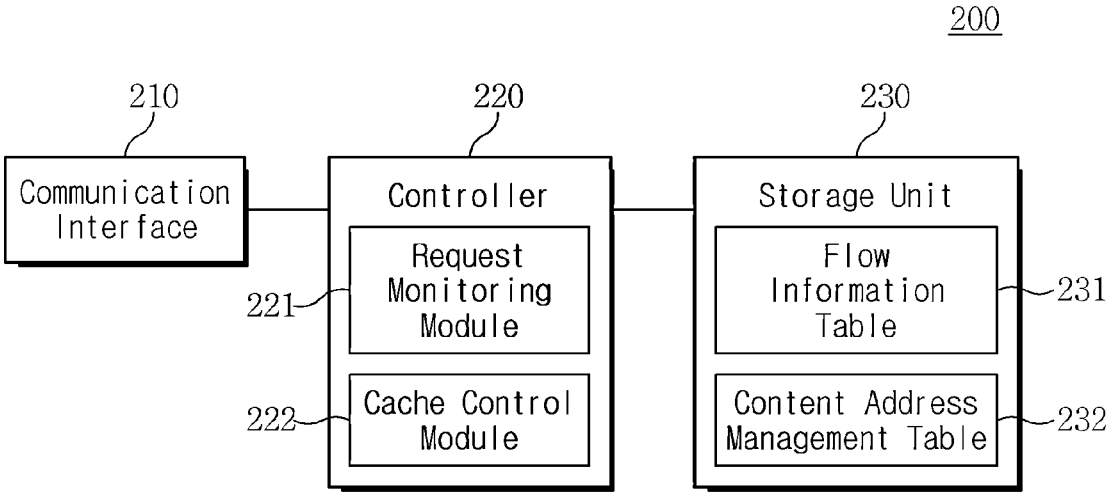
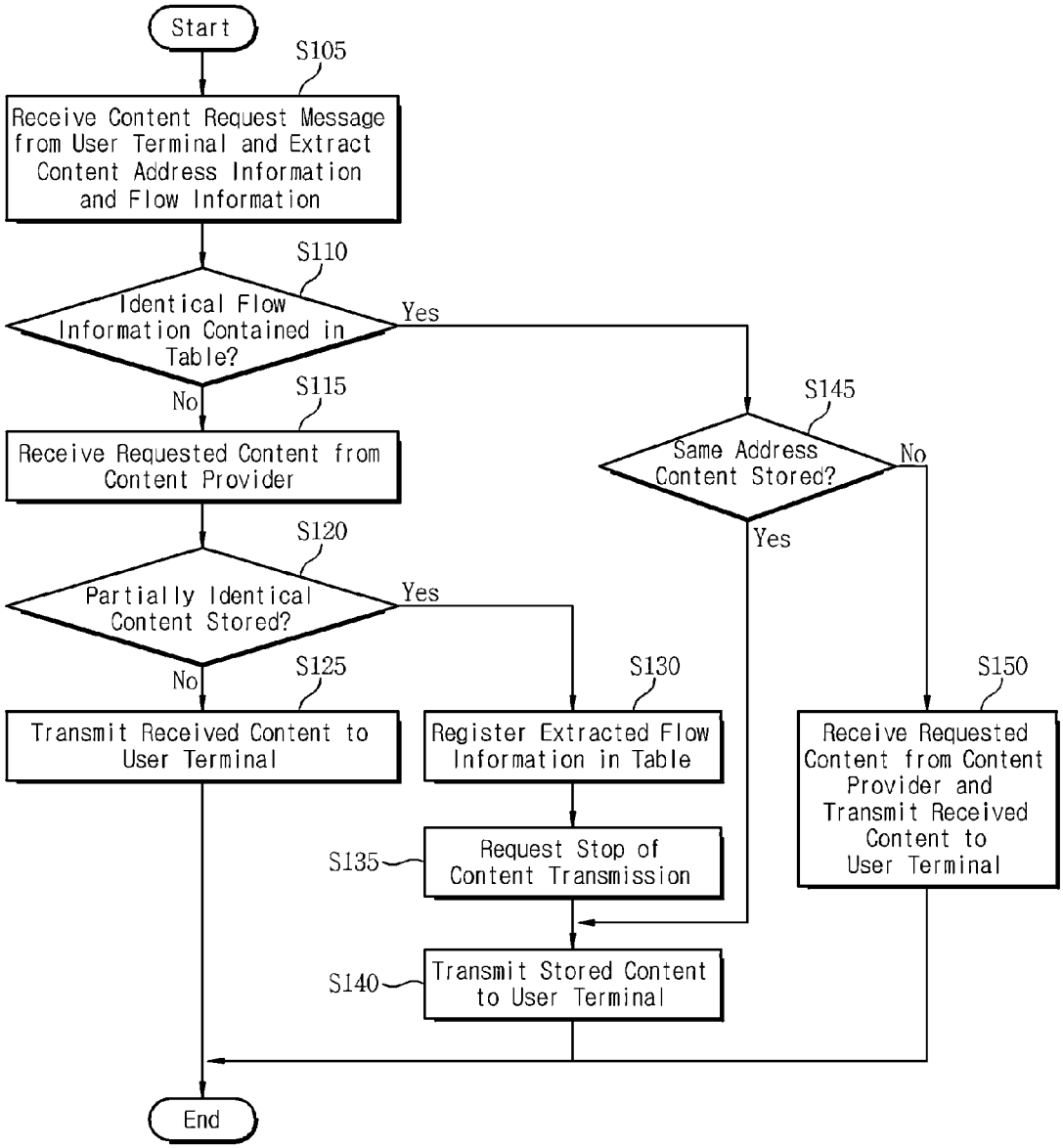

200
210
220
230
Communication Interface
Controller
Request Monitoring Module
221
Cache Control Module
222
Storage Unit
Flow Information Table
231
Content Address Management Table
232

FIG. 6


Start
S105
Receive Content Request Message from User Terminal and Extract Content Address Information and Flow Information
S110
Identical Flow Information Contained in Table?
Yes
No
S115
Receive Requested Content from Content Provider
S120
Partially Identical Content Stored?
Yes
No
S125
Transmit Received Content to User Terminal
S130
Register Extracted Flow Information in Table
S135
Request Stop of Content Transmission
S140
Transmit Stored Content to User Terminal
S145
Same Address Content Stored?
No
Yes
S150
Receive Requested Content from Content Provider and Transmit Received Content to User Terminal
End

LOCAL CACHING DEVICE, SYSTEM AND METHOD FOR PROVIDING CONTENT CACHING SERVICE

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to and benefit of Patent Application Serial No. 10-2012-0059293, filed on Jun. 1, 2012 in Korea, which is hereby incorporated by reference herein in its entirety.

TECHNICAL FIELD

The present disclosure relates to a local caching device and method for providing a content caching service to prevent, in some embodiments, redundant content transmission and hence reduce traffic on a network.

BACKGROUND

The statements in this section merely provide background information related to the present disclosure and may not constitute prior art.

With a rapid propagation of smart phones and continuing increases in the number of content providers using smart phones, there is a growing tendency toward an increase in traffic of mobile communication networks. The inventor(s) has experienced that this may often cause the deterioration of service quality due to a decrease in a transmission rate of contents such as videos, audios, images, applications, and the like.

Meanwhile, a recent growth of content transmission technology allows transmission of large-capacity files in online video services such as VOD (Video On Demand) or live streaming, in music streaming services, and in file upload and download. Thus, a variety of services for delivering large-capacity contents are provided.

Normally such content providing services tend to deliver redundant contents to users in the same domain or the same radio coverage even though the frequency of content delivery depends on its popularity. The inventor(s) has noted that as various content providing services are widely used today, transmission of redundant contents occupies an increasing part of network traffic.

In a situation that network traffic sharply increases due to transmission of large-capacity contents, the inventor(s) has experienced that transmission of redundant contents further increases a traffic load of the communication network. In view of this, the inventor(s) has noted that a CDN (Content Delivery Network) service is used to stably deliver various types of contents such as movies, music video, and the like to end-users. In the CDN service, replicas of contents are stored in a plurality of local cache servers distributed in a network. A load balancer, also referred to as a GLB (Global Load Balance) server, selects an optimal cache server among the local cache servers, and the selected cache server delivers requested content to a user terminal.

This CDN architecture provides a solution to obviate several problems including data loss, bottlenecks, reduced transmission rate, network instability such as discontinuous data transmission, and the like.

In the CDN service, content caching technology is used for selectively caching contents in a plurality of local caching devices distributed in a network. Content caching should consider the size of a storage space in a local caching device, the time required to determine whether requested content is cached in the local caching device, and a cache hit rate that indicates a percentage that the requested contents are contained in the local caching device.

Particularly, in case of adapted content providing techniques (e.g., HTTP Live Streaming (HLS)) to transmit content by varying its resolution according to link quality or device performance, content is divided into a plurality of chunks and transmitted by the chunks. Therefore, if it is determined on the basis of parts of content whether the content is cached, service efficiency may be lowered due to a small amount of data transmitted from a local caching device to a user terminal. Additionally, some adapted content providing techniques periodically change an encryption key of content. If such an encryption key is changed, content data is changed through encryption in spite of having the same URL, and hence it is impossible to determine on the basis of URL whether the content is cached.

SUMMARY

In accordance with some embodiments, a local caching device includes a storage unit, a communication interface, and a controller. The storage unit is configured to store some or all contents provided from at least one content provider to at least one user terminal. The communication interface is configured to transmit and receive data between the at least one content provider and the at least one user terminal. The controller is configured to receive, from the content provider, content requested by the user terminal, register flow information of the requested content if the storage unit stores content which is at least partially identical to the received content, and determine whether the requested content is stored in the storage unit when content having the same flow information as the registered flow information is requested.

In accordance with some embodiments, the local caching device is configured to receive, from a content provider, at least one part of content requested by a user terminal; determine whether the requested content is stored in a storage unit of the local caching device, based on the received at least one part of the requested content; register flow information of the requested content in a flow information table of the storage unit if the requested content is stored in the storage unit. And when content having the same flow information as the registered flow information is requested, the local caching device is configured to determine whether the requested content is stored in the storage unit, based on content address information.

In accordance with some embodiments, the system of providing a content caching service comprises a content provider and a local caching device. The content provider is configured to providing some or all contents. The local caching device includes a storage unit, a communication interface, and a controller. The storage unit is configured to store some or all contents provided from at least one content provider to at least one user terminal. The communication interface is configured to transmit and receive data between the at least one content provider and the at least one user terminal. The controller is configured to receive, from the content provider, content requested by the user terminal, register flow information of the requested content if the storage unit stores content which is at least partially identical to the received content, and determine whether the requested content is stored in the storage unit when content having the same flow information as the registered flow information is requested.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a schematic block diagram of a content caching service system in accordance with at least one embodiment.

FIG. **2** is a schematic block diagram of a local caching device distribution structure in the content caching service system in accordance with at least one embodiment.

FIG. **3** is a schematic diagram of a structure of adapted type content in accordance with at least one embodiment.

FIG. **4** is a schematic diagram of an exemplary flow information table and an exemplary content address management table used in the local caching device in accordance with at least one embodiment.

FIG. **5** is a schematic block diagram of a local caching device in accordance with at least one embodiment.

FIG. **6** is a flow diagram of a method for providing a content caching service in accordance with at least one embodiment.

DETAILED DESCRIPTION

In the following description, numerous specific details are set forth. However, it is understood that various embodiments of the disclosure are practiced without these specific details. In other instances, well-known functions or configurations have not been shown in detail in order not to obscure understanding of this description. The same reference numbers will be used throughout this specification to refer to the same or like parts.

To aid in understanding of the present disclosure, the terms used in the following description are defined as follows.

'Flow information' refers to information that defines a flow associated with transmission of specific content to a user terminal. In some embodiments, the flow information may be formed as at least one combination of IP address information, port information and protocol information of both a source and a destination. In some embodiments, the flow information is formed as a combination of IP address information of a destination, port information of a destination, and IP address information of a source in order to identify a flow of adapted type content.

'Content address information' refers to the location of content in a network and may be a URL (Uniform Resource Locator) including a protocol type, the domain name or IP address of a content provider, and a file path name of content, for example.

'Content identification information' is information for identifying content stored in a local caching device. In some embodiments, the content identification information refers to a value generated by extracting at least part of a content request message or processing (e.g., hashing) at least part of the content. In at least one embodiment, the content identification information is generated on the basis of at least part of the content. For example, the content identification information includes at least one of prefix information having a predetermined length, a hash value obtained by processing the prefix information using a predetermined hash function, and metadata of the content.

'Content' can be, for example, text message, web content, video, audio, images, applications, and etc. 'Content' can be provided in a streaming or download manner. 'Content' can be divided into one or more parts in a predetermined chunk unit and stored, wholly or partly, at a single or multiple storages of at least one local caching device, at least one user terminal, and/or at least one content providing device of one or more content providers.

'A cache hit' refers to the existence of requested content in a cache. In some embodiments of this disclosure, a "cache hit" means that the requested content is contained in one or more local caching devices.

FIG. **1** is a schematic block diagram of a content caching service system in accordance with at least one embodiment.

Referring to FIG. **1**, the content caching service system includes at least one user terminal **100** (just shown as a single user terminal in FIG. **1** for convenience), at least one local caching device **200** (just shown as a single local caching device in FIG. **1** for convenience), and at least one content provider **300** (just shown as a single content provider in FIG. **1** for convenience), which are connected to each other through a network **400**.

The user terminal **100**, also referred to user equipment (UE), is a device that is connected to the network **400** to use content provided through the network **400**. The user terminal **100** requests the content provider **300** to provide specific content and receives the requested content or other content transmitted from either the content provider **300** or the local caching device **200** at the request of the user terminal **100**. The user terminal **100** may include a desktop PC, a notebook computer, a tablet PC, a smart phone, a PDA (Personal Digital Assistant), an Internet TV (i.e., a smart TV), or any other electronic device having a communication function.

The local caching device **200** is distributed in the network **400**, stores contents provided by the content provider **300** temporarily or for a predetermined time, and provides the stored contents to the user terminal **100** in place of the content provider **300** when the user terminal **100** requests the content. For this, the local caching device **200** performs, based on various caching schemes, a caching operation of copying some or all contents provided to the user terminal **100** by the content provider **300** and storing the copied content. In addition, when a content request message being transmitted from the user terminal **100** to the content provider **300** is received, the local caching device **200** compares flow information extracted from the content request message with flow information of a previous cache hit. In this disclosure, flow information of a previous cache hit refers to flow information of a currently activated session which corresponds to a cache hit made using a part of content as a key.

If the extracted flow information is identical to that of a previous cache hit, the local caching device **200** determines, based on content address information of content requested by the user terminal **100**, whether the requested content is stored or not (namely, whether it results in a cache hit or a cache miss). Otherwise, the local caching device **200** receives the requested content from the content provider **300** and then, by using at least part of the received content as a key, determines whether the requested content is stored or not. Furthermore, in case of adapted type content, the local caching device **200** determines a cache hit or a cache miss by using at least part of content, and in case of a cache hit, registers flow information of the content in a flow information table. Thereafter, when there is a request for content having flow information matched with that registered in the flow information table, the local caching device **200** simply determines a cache hit or a cache miss on the basis of content address information. Therefore, with regard to adapted type content divided into chunks and transmitted by the chunks, the amount of transmittable data from the local caching device **200** to the user terminal **100** is increased and consequently service efficiency is enhanced.

As the result of determination based on either at least part of the received content or content address information, if the requested content is not stored (i.e., a cache miss), the local caching device **200** receives the requested content from the content provider **300** and then transmits the received content to the user terminal **100**.

As the result of determination based on either at least part of the received content or content address information, if the requested content is stored (i.e., a cache hit), the local caching device **200** retrieves the stored content and then transmits the stored content to the user terminal **100**.

In order to determine a cache hit or a cache miss as discussed above, the local caching device **200** extracts, from the content request message, IP address information and port information of the user terminal **100** and IP address of the content provider **300**, and manages a combination of them as flow information of a cache hit. Additionally, the local caching device **200** matches the content identification information, created using at least part of the requested content, with content address information, and manages them. Here, such management of flow information of a cache hit, content identification information and content address information is performed regarding contents stored in the local caching device **200**.

In case where the content provider **300** provides contents through an adapted content transmission technique, for example, in case of HLS (HTTP Live Streaming), each content includes two or more content data having different resolutions, and each content data is divided into a plurality of chunks. Then specific content data having a resolution corresponding to link quality or device performance is selected and transmitted by the chunks. Additionally, content may be encrypted through an encryption key periodically changed.

When any content is requested for the first time, corresponding flow information is not yet registered in the flow information table. Therefore, the local caching device **200** receives a part of the requested content from the content provider **300** and then checks, by using the received part as a key, whether the requested content is stored. Thus, considering a change or not of an encryption key, the local caching device **200** can exactly determine caching or not of the content and, in case of a cache hit, regard the remaining data of stored content as being encrypted using the same encryption key. Accordingly, when the user terminal **100** requests the remaining data, the local caching device **200** can check a cache hit or not of the requested content by simply using content address information only and thereby enhance the service efficiency.

The configuration and operation of the local caching device **200** will be described in detail later.

Although the local caching device **200** is illustrated as a single device in FIG. **1**, this is exemplary only and not to be considered as a limitation. Alternatively, a plurality of local caching devices **200** may be distributed in the network **400**.

The content provider **300** is a service providing device that provides various types of contents, for example, video files, audio files, web pages, etc. through the network **400** in a streaming or download manner. The content provider **300** may be a server (e.g., a computer system) that provides video sharing sites through which a charged or free video is uploaded, viewed or shared, application stores through which mobile contents are sold, an IPTV broadcast service through the Internet, and the like.

The network **400** through which contents are transmitted among the user terminal **100**, the local caching device **200** and the content provider **300** may include various communication networks currently used or expected to be used in the future and their unified networks. Specifically, the network **400** may include IP based wired/wireless communication networks such as the Internet, mobile communication networks such as the LTE (Long Term Evolution) network and the WCDMA network, various wireless networks such as the Wi-Fi network, and any other mobile network. The local caching device **200** can be used to reduce redundant content transmission and traffic in such a network.

Particularly, in some embodiments, the local caching device **200** may be distributed at edges of the network **400**. This case is shown in FIG. **2**.

FIG. **2** is a schematic block diagram of a local caching device distribution structure in the content caching service system in accordance with at least one embodiment.

Referring to FIGS. **1** and **2**, the network **400** includes wireless or wired access networks **410** and **420** to which the user terminal **100** is connected, and a core network **430** that connects the wireless or wired access networks **410** and **420**.

The wireless access network **410** refers to a subscriber network capable of transmitting or receiving data to or from the user terminal **100** in various wireless communication manners, and may include a mobile communication network and Wi-Fi network. The wired access network **420** refers to a subscriber network connected to the user terminal **100** in a wired manner to transmit or receive data to or from the user terminal **100**, and may include FTTH (Fiber To The Home).

The local caching devices **200** (also denoted by reference numerals **200***a* and **200***b* in FIG. **2**) are distributed at edge nodes of the network **400**. Specifically, the local caching devices **200***a* and **200***b* are connected to switching devices (e.g., routers, etc.) **431***a*, **431***b* and **431***c* which are edge nodes of the core network **430** and linked to the wireless/wired access networks **410** and **420**. Therefore, each of the local caching devices **200***a* and **200***b* can provide the content caching service to the user terminal **100** connected to the wireless/wired access networks **410** and **420**.

Particularly, when the content caching service is applied to a mobile network such as a mobile communication network, the local caching device **200** may be distributed in each wireless access network including a plurality of base stations (BSs), also referred to as base transceiver stations (BTSs), nodeBs, eNodeBs, etc., and a base station controller (BSC) such as a radio network controller (RNC) in the mobile network. In this case, the local caching device **200** may be connected to an edge node (e.g., a switching device) of a mobile communication system connected to each wireless access network to support transmission of content to a user terminal connected to each wireless access network.

In order to promote understanding of the content caching service, FIG. **3** shows, in a schematic diagram, a structure of adapted type content in accordance with at least one embodiment.

Referring to FIG. **3**, in case of an adapted content transmission technique such as HLS, content **10** may include two or more content data **11**, **12** and **13** encoded with different resolutions. In other words, each of content data **11**, **12** and **13** represents the same content **10**, but at a different resolution. In some embodiments, content data **11**, **12** and **13** has a resolution of 1024K, 720K and 480K, for example. In this case, the content **10** may be provided to the user terminal **100** at a specific resolution selected from 1024K, 720K and 480K, depending on link quality or device performance. In at least one embodiment, the specific resolution is variable as the link quality or device performance changes.

Additionally, each content data **11**, **12** and **13** encoded with different resolutions is divided into a plurality of chunks **A1**~**A3**, **B1**~**B3** and **C1**~**C3** having a given size. In case of video content, for example, the size of single chunk data may be set to about ten seconds.

As such, the content **10** having various resolutions is transmitted by the chunks after content data with suitable resolution is selected depending on at least one of link quality and performance of the user terminal **100**.

If content is not an adapted type, the GET message is transmitted normally about once. However, in case of adapted type content, a content request may occur by the chunks and therefore the GET message is transmitted several times.

Additionally, the adapted type content **10** may be encrypted, and an encryption key may be periodically changed. In some embodiments, all content data **11**, **12** and **13** of the content **10** are encrypted with the same encryption key. Therefore, if the encryption key is changed, the content data transmitted is also changed but content address information of the content **10** is unchanged.

When the adapted type content **10** is requested, the local caching device **200** receives at least part of the requested content from the content provider **300** in response to the first GET message, compares contents by using the received part as a key, and checks whether the requested content is stored, especially, whether any content encrypted with a specific encryption key currently used by the content provider **300** is stored. If the local caching device **200** caches the requested content, but an encryption key thereof is changed, the local caching device **200** determines that the requested content is not stored when determining on the basis of at least part of the received content whether the requested content is stored or not. If an encryption key is not changed, the local caching device **200** determines that the requested content is stored.

That is to say, as the result of determination using at least part of content as a key, if the same content is stored, it is determined that content data encrypted with a specific encryption key currently applied to the requested content is stored in the local caching device **200**. Therefore, in response to subsequent requests for the adapted type content **10** from the user terminal **100**, the local caching device **200** can determine on the basis of content address information whether the requested content is stored or not.

For this, the local caching device **200** stores flow information regarding a content request of a previous cache hit. Thereafter, whenever a content request message is received, the local caching device **200** extracts flow information from the received message and checks whether the extracted flow information is identical to the stored flow information of a previous cache hit. If not identical, the local caching device **200** determines a cache hit or not through comparison of at least part of content. If identical, the local caching device **200** determines a cache hit or not of the requested content through a simple comparison of the content address information only.

Additionally, for the above operation, the local caching device **200** may have a flow information table and a content address management table. The flow information table manages flow information regarding a content request of a cache hit. The content address management table manages content identification information and content address information regarding respective contents stored in the local caching device **200**.

Section (a) of FIG. **4** shows an example of the flow information table in which source address information and destination address information are matched with each other as flow information regarding a content request of a cache hit. Here, the source address information indicates a source of content of a cache hit, namely, the address information of the content provider **300**, and is set as IP address information (e.g., Server**1**_IP, Sever**2**_IP, etc.). The destination address information indicates a destination of content of a cache hit, namely, the address information of the user terminal **100**, and is set as both IP address information (e.g., UE_IP) and port information (e.g., UE_Port).

Section (b) of FIG. **4** shows an example of the content address management table. In some embodiments, the content address management table includes a first field that records content identification information created using at least part of each of contents stored in the local caching device **200**, and a second field that records one or more content address information matched with the content identification information. As defined above, the content identification information is created by extracting at least part of corresponding content or processing (e.g., hashing) at least part of the content. For example, the content identification information may include at least one of prefix information having a predetermined length, a hash value obtained by processing the prefix information using a predetermined hash function, and metadata of the content.

Now, the configuration and operation of the local caching device **200** will be described in detail with reference to FIG. **5**.

FIG. **5** is a schematic block diagram of a local caching device in accordance with at least one embodiment.

Referring to FIG. **5**, the local caching device **200** includes a communication interface **210**, a controller **220**, and a storage unit **230**.

The communication interface **210** is connected to the network **400** to transmit or receive data through the network **400**. Particularly, the communication interface **210** is connected to the network **400** through which data is transmitted between at least one content provider **300** and at least one user terminal **100**, and transmits or receives data to or from the content provider **300** and the user terminal **100** through the network **400**. The communication interface **210** may include one or more communication modules that process transmission and reception in a wired or wireless manner according to the type of the network **400**. The communication interface **210** also can communicate to each other and various networks including, but not limited to, cellular, Wi-Fi, LAN, WAN, CDMA, WCDMA, GSM, LTE and EPC networks, and cloud computing networks.

The storage unit **230** stores some or all contents provided from at least one content provider **300** to at least one user terminal **100**. Additionally, the storage unit **230** may further store the flow information table **231** that manages information about a flow of a currently activated session corresponding to a cache hit, and the content address management table **232** that manages content address information about one or more contents stored in the storage unit **230**. The flow information table **231** and the content address management table **232** may be constructed as shown in FIG. **4** and managed by the controller **220**.

The controller **220** controls the overall caching service operation of the local caching device **200**. Upon reception of a content request message from the user terminal **100** through the communication interface **210**, the controller **220** checks whether the requested content is stored in the storage unit **230**. If stored (i.e., a cache hit), the controller **220** retrieves the requested content from the storage unit **230** and provides the requested content to the user terminal **100** in place of the content provider **300**. If not stored, the controller **220** receives the requested content from the content provider **300** and delivers the received content to the user terminal **100** while storing the received content in the storage unit **230**.

For the above processing, the controller **220** may have a request monitoring module **221** and a cache control module **222**.

The request monitoring module **221** monitors all content request messages being transmitted from the user terminal **100** to the content provider **300**. Specifically, the request monitoring module **221** not only delivers to the content provider **300** all the content request messages received from the

user terminal **100**, but also extracts information, e.g., source address information, destination address information, URL information corresponding to the requested content, etc., regarding all content request messages transmitted from the user terminal **100** to the content provider **300**.

The cache control module **222** stores (i.e., caches), in the storage unit **230**, contents being transmitted from the content provider **300** to the user terminal **100**. Specifically, the cache control module **222** receives, as a response to the content request message, a response of a particular flow transmitted from the content provider **300** to the user terminal **100** and stores it in the storage unit **230**. At this time, the cache control module **222** obtains information about the particular flow by querying the request monitoring module **221**, tags URL information which is one of the obtained information and corresponds to content address information associated with relevant content, and stores them.

Meanwhile, a process of determining whether the requested content is stored is performed as follows.

When a content request message being transmitted from the user terminal **100** to the content provider **300** is received, the controller **220** receives at least part of the content transmitted from the content provider **300** in response to a content request, and then based on the received part of the content, determines whether the requested content data is stored in the storage unit **230** (i.e., whether there is a cache hit or not). As the result of determination, if the requested content data is stored in the storage unit **230**, the controller **220** checks whether the stored content data is a part of adapted type content. This may be performed by checking whether a file name recorded in a URL corresponding to content address information has a specific filename extension (e.g., ts) or checking whether there is a past record that continuous content requests occur more than a given number of times with regard to corresponding content.

As the result of the check, if the content data of a current cache hit is a part of adapted type content, the controller **220** extracts flow information corresponding to the content data and then stores as a flow of a cache hit in the flow information table **231**. At this time, by counting a cache hit or not of each flow, the controller **220** may register flow information of only a flow of continuous cache hits more than a given number of times in the flow information table **231**.

Additionally, as to a content request regarding a flow registered in the flow information table **231**, the controller **220** changes a way of determining whether the requested content is stored in the storage unit **230**, namely, determines based on content address information.

Specifically, the controller **220** compares flow information contained in the content request message with flow information of a previous cache hit. If both are identical to each other, the controller **220** determines, based on content address information of the requested content, whether the requested content is stored in the storage unit **230**.

For this, the request monitoring module **221** of the controller **220** monitors content request messages from the user terminal **100** and notifies the cache control module **222** of a content request having the same flow information as registered in the flow information table **231** such that the cache control module **222** determines a cache hit or not on the basis of content address information corresponding to the request. As the result of determination based on content address information, if the requested content is stored in the storage unit **230**, the cache control module **222** transmits the requested content to the user terminal **100** in place of the content provider **300**.

If the requested content is not stored in the storage unit **230**, the controller **220** delivers the content request message to the content provider **300**. Then the controller **220** receives the requested content from the content provider **300** and then, based on at least part of the received content, determine again whether the requested content is stored in the storage unit **230**.

If it is still determined that the requested content is not stored in the storage unit **230**, the controller **220** continues to receive the content from the content provider **300**, transmits the received content to the user terminal **100**, and stores the received content in the storage unit **230**.

If it is newly determined, based on at least part of the received content, that the requested content is stored in the storage unit **230**, the controller **220** requests the content provider **300** to stop content transmission. This reduces traffic in the section between the content provider **300** and the local caching device **200**. A message for requesting a stop of content transmission may be HTTP RST (Reset) message, for example.

Additionally, during the above process, the controller **220** not only further records, in the content address management table **232**, at least one of content address information of the requested content and content identification information created using at least part of content received from the content provider **300**, but also further records, in the flow information table **231**, flow information extracted from the content request message of the user terminal **100**. Further recorded information will be used in subsequent content requests.

Now, a content caching service method will be described in detail with reference to FIG. **6**.

FIG. **6** is a flow diagram of a method for providing a content caching service in accordance with at least one embodiment.

As discussed above, the local caching device **200** has the flow information table **231** and the content address management table **232**, manages flow information regarding contents of previous cache hits through the flow information table **231**, and manages content identification information and content address information regarding contents stored in the storage unit **230** through the content address management table **232**. In some embodiments, flow information registered in the flow information table **231** is flow information regarding adapted type contents and may be flow information regarding currently activated session.

In some embodiments, when the user terminal **100** requests content, the local caching device **200** receives at least part of the requested content from the content provider **300** and, based on the received parts, determines whether the requested content is stored in the storage unit **230**. If stored, the local caching device **200** registers flow information of the requested content in the flow information table **231**. Thereafter, as to content having the same flow information as registered in the flow information table **231**, the local caching device **200** determines whether the requested content is stored in the storage unit **230**, based on content address information instead of relying upon received parts of the content. Therefore, the local caching device **200** can effectively determine a cache hit or not of adapted type content that is divided into a plurality of chunks and requested and transmitted by the chunks.

For example, as shown in FIG. **6**, the local caching device **200** receives a content request message being transmitted from the user terminal **100** to the content provider **300** and extracts, from the content request message, flow information and content address information regarding the requested con-

tent (step S105). Here, the content request message may be an HTTP GET message, for example.

Additionally, the local caching device **200** determines, by comparison, whether the flow information table **231** contains flow information identical to the extracted flow information (step S110). Here, the flow information registered in the flow information table **231** is flow information regarding content of a previous cache hit. For example, any content data of certain adapted type content **10** as shown in FIG. **3** has been requested and determined as a cache hit, flow information regarding the adapted type content **10** is registered in the flow information table **231**. Thereafter, if a content request message that requests other content data of the adapted type content **10** is received, flow information extracted from this content request message becomes identical to that registered in the flow information table **231**.

Therefore, as the result of determination at step S110, if the flow information table **231** contains flow information identical to the extracted flow information, the local caching device **200** determines, based on content address information (e.g., URL) extracted from the content request message, whether the requested content is stored in the storage unit **230** (step S145).

As the result of determination at step S145, if content having the same address information as the extracted content address information is stored in the storage unit **230**, the local caching device **200** transmits the stored content to the user terminal **100** (step S140).

In contrast, as the result of determination at step S145, if content having the same address information as the extracted content address information is not stored in the storage unit **230**, the local caching device **200** receives the requested content from the content provider **300**, delivers the received content to the user terminal **100**, and stores the received content in the storage unit **230** (step S150).

Meanwhile, as the result of comparison of flow information at step S110, if the flow information table **231** does not contain flow information identical to the extracted flow information, the local caching device **200** receives the requested content from the content provider **300** (step S115), and then determines whether the storage unit **230** stores any content at least partially identical to the received content (step S120). This step S120 may be performed by searching the content address management table **232** by means of content identification information created using at least part of the received content.

As the result of determination at step S120, if the identical content is not stored, it is eventually determined that the requested content is not stored in the local caching device **200**. Therefore, the local caching device **200** receives the requested content from the content provider **300**, delivers the received content to the user terminal **100**, and stores the received content in the storage unit **230** (step S125).

In contrast, as the result of determination at step S120, if the at least partially identical content is stored in the storage unit **230**, the local caching device **200** registers the flow information extracted from the content request message in the flow information table **231** (step S130).

In some embodiments, this step S130 may be performed only for adapted type contents. For this case, the local caching device **200** may further perform step of determining whether the requested content is adapted type content, and if so, may perform step S130. In order to confirm adapted type content, the local caching device **200** may check a filename extension recorded in content address information of the requested content. Alternatively, the local caching device **200** may analyze content requests and cache hits with regard to flow information. If content has been requested more than a given number of times and stored in the storage unit **230**, the local caching device **200** may perform step S130.

In alternative embodiments, step S130 may be performed simultaneously with or after one of steps S135 and S140.

Additionally, if any content at least partially identical to the received content is stored in the storage unit **230**, the local caching device **200** may request the content provider **300** to stop content transmission (step S135).

Also, if any content at least partially identical to the received content is stored in the storage unit **230**, the local caching device **200** retrieves the content from the storage unit **230** and transmits the stored and retrieved content to the user terminal **100** (step S140).

Meanwhile, as to any content stored in the storage unit **230** at steps S125 and S150, the local caching device **200** creates content identification information by using at least part of the content, extracts content address information, and registers the extracted content address information in the content address management table **232** such that the extracted content address information registered therein may be used later in determining whether the same content is requested.

The above-discussed process may be performed in case where the requested content is cached as adapted type content without a change of an encryption key, and the local caching device **200** may reduce traffic by using cached contents. Namely, the local caching device **200** transmits first a part of content received for determining content caching or not. After determination of caching or not, the local caching device **200** retrieves subsequent data from the storage unit **230** and transmits the stored and retrieved subsequent data to the user terminal **100**.

As discussed above, in case of adapted type content cached in the local caching device **200**, if determination based on a part of content results in a cache hit, and if a content request message sequentially occurs regarding the remaining data of the adapted type content, at step S120, source address information extracted from the content request message becomes identical to flow information of a previous cache hit.

If any content data of the adapted type content **10** as shown in FIG. **3** is requested, the local caching device **200** determines caching or not of the requested content by comparing a part of content. If the requested content is cached, the local caching device **200** registers flow information for identifying the adapted type content **10** in the flow information table **231**. Therefore, when the other content data of the adapted type content **10** is requested, the local caching device **200** can determine caching or not through a simple comparison of content address information only.

As discussed above, when the local caching device **200** distributed on the network **400** caches some or all contents of the content provider **300** and then provides cached content to the user terminal **100** in place of the content provider **300** in response to a request for the same content, the local caching device **200** checks whether flow information contained in the content request message is identical to that of a previous cache hit. If identical, the local caching device **200** determines caching or not of the requested content on the basis of address information of the requested content. If not identical, the local caching device **200** receives the requested content from the content provider **300** and then determines caching or not of the requested content on the basis of at least part of the received content. This enhances efficiency of cache hit determination processing.

Particularly, as to adapted type content that is divided into chunks and periodically changes an encryption key for content, this technique disclosed herein may reduce the time

required to determine the existence of the same content and also realize more efficient service operation.

The method of providing content caching service according to some embodiments of the present disclosure is implemented as program commands that can be executed by various computer systems and be recorded in any non-transitory, and written to a computer-readable recording medium. The computer-readable recording medium includes programs, data files, data structures, etc. alone or in combination. The program commands written to the medium are designed or configured especially for the present disclosure, or known to those skilled in computer software. Examples of the computer-readable recording medium include magnetic media such as a hard disk, a floppy disk, and a magnetic tape, optical media such as a CD-ROM and a DVD, magneto-optical media such as a floptical disk, and a hardware device configured especially to store and execute a program command, such as a ROM, a RAM, and a flash memory. Examples of a program command include a premium language code executable by a computer using an interpreter as well as a machine language code generated by a compiler. The hardware device is configured to operate as one or more software modules to implement the present disclosure or vice versa. In some embodiments, one or more of the processes or functionality described herein is/are performed by specifically configured hardware (e.g., by one or more application specific integrated circuits or ASIC(s)). Some embodiments incorporate more than one of the described processes in a single ASIC. In some embodiments, one or more of the processes or functionality described herein is/are performed by at least one processor which is programmed for performing such processes or functionality.

The detailed description of the preferred embodiments of the present disclosure has been given to enable those skilled in the art to implement and practice the disclosure. Although the disclosure has been described with reference to the various embodiments, those skilled in the art will appreciate that various modifications and variations can be made in the present disclosure without departing from the subject matter, the spirit and scope of the disclosure. Specific terms used in this disclosure and drawings are used for illustrative purposes and not to be considered as limitations of the present disclosure.

What is claimed is:

1. A local caching device, comprising:

a storage unit configured to store some or all contents provided from at least one content provider to at least one user terminal;

a communication interface configured to transmit and receive data between the at least one content provider and the at least one user terminal; and

a controller configured to

receive, from the content provider, content requested by the user terminal,

register flow information of the requested content when the storage unit stores content which is at least partially identical to the received content,

wherein the flow information includes source address information indicating a source of content of a cache hit, and destination address information indicating a destination of content of the cache hit, and

determine whether the requested content is stored in the storage unit when content having the same flow information as the registered flow information is requested,

wherein the storage unit is further configured to store a content address management table which includes:

a first field configured to record content identification information including at least one of information extracted from at least part of contents stored in the local caching device and information hashed from at least part of the contents stored in the local caching device; and

a second field configured to record one or more content URL address information matched with the content identification information, and

wherein the content identification information includes all of

prefix information having a predetermined length,

a hash value obtained by processing the prefix information using a predetermined hash function, and

metadata of the received content.

2. The local caching device of claim **1**, wherein the controller is further configured to

determine whether the received content is at least one part of adapted type content, and

register flow information of the received content in a flow information table of the storage unit when the received content is the at least one part of adapted type content.

3. The local caching device of claim **1**, wherein the controller is further configured to register the flow information of the received content in a flow information table of the storage unit when the content is requested more than a given number of times and stored in the storage unit.

4. The local caching device of claim **1**, wherein, when content at least partially identical to the received content or content corresponding to content address information is not stored in the storage unit, the controller is further configured to

receive the requested content from the content provider,

transmit the received content to the user terminal, and

store the received content in the storage unit.

5. The local caching device of claim **1**, wherein when content at least partially identical to the received content is stored in the storage unit, the controller is further configured to request the content provider to stop content transmission.

6. The local caching device of claim **1**, wherein the controller is further configured to

extract the flow information corresponding to the received content, and

store the extracted flow information as a flow of the cache hit in a flow information table of the storage unit.

7. The local caching device of claim **6**, wherein the controller is further configured to

count a cache hit or not of each flow, and

register the flow information of a flow of continuous cache hits more than a given number of times in the flow information table of the storage unit.

8. The local caching device of claim **1**, wherein the controller further comprises

a request monitoring module configured to monitor some or all content request messages being transmitted from the at least one user terminal to the at least one content provider, and

a cache control module configured to store, in the storage unit, some or all contents being transmitted from the at least one content provider to the at least one user terminal.

9. The local caching device of claim **1**, wherein the source address information includes IP address information of the source, and the destination address information include IP address information and port information of the destination.

10. A method of providing a content caching service, the method performed by a local caching device and comprising:

receiving, from a content provider, at least one part of content requested by a user terminal;

determining whether the requested content is stored in a storage unit of the local caching device, based on the received at least one part of the requested content;

registering flow information of the requested content in a flow information table of the storage unit when the requested content is stored in the storage unit,

wherein the flow information includes source address information indicating a source of content of a cache hit, and destination address information indicating a destination of content of the cache hit, and

when content having the same flow information as the registered flow information is requested, determining whether the requested content is stored in the storage unit, based on content address information;

matching, for the stored content, content identification information created using at least one part of the received content and the content URL address information of the received content; and

storing the matched information in a content address management table of the storage unit,

wherein the content address management table includes:

a first field records the content identification information including at least one of information extracted from at least part of contents stored in the local caching device and information hashed from at least part of the contents stored in the local caching device; and

a second field records one or more the content URL address information matched with the content identification information, and

wherein the content identification information includes all of

prefix information having a predetermined length,

a hash value obtained by processing the prefix information using a predetermined hash function, and

metadata of the received content.

11. The method of claim **10**, wherein the registering of the flow information includes

when the content corresponding to the flow information is requested more than a given number of times and stored in the storage unit, registering the flow information in the flow information table of the storage unit.

12. The method of claim **10**, wherein the registering of the flow information includes

determining whether the received content is a part of adapted type content, and

registering the flow information of the requested content in the flow information table of the storage unit when the received content is a part of adapted type content.

13. The method of claim **10**, further comprising:

determining whether the requested content is stored in the storage unit, based on the content address information or at least one part of the received content; and

transmitting the stored content to the user terminal when the requested content is determined as stored in the storage unit.

14. The method of claim **10**, further comprising:

determining whether the requested content is stored in the storage unit, based on the content address information or at least one part of the received content;

when the requested content is determined as not stored in the storage unit,

receiving the requested content from the content provider; and

transmitting the received content to the user terminal while storing the received content in the storage unit.

15. A system of providing a content caching service, comprising:

a content provider configured to providing some or all contents; and

a local caching device configured to communicate with the content provider, the local caching device including:

a storage unit configured to store the provided some or all contents provided to at least one user terminal;

a communication interface configured to transmit and receive data between the at least one content provider and the at least one user terminal; and

a controller configured to

receive, from the content provider, content requested by the user terminal,

register flow information of the requested content when the storage unit stores content which is at least partially identical to the received content,

wherein the flow information includes source address information indicating a source of content of a cache hit, and destination address information indicating a destination of content of the cache hit, and

wherein the source address information includes IP address information of the source, and the destination address information include IP address information and port information of the destination, and

determine whether the requested content is stored in the storage unit when content having the same flow information as the registered flow information is requested,

wherein the storage unit is further configured to store a content address management table which includes:

a first field configured to record content identification information including at least one of information extracted from at least part of contents stored in the local caching device and information hashed from at least part of the contents stored in the local caching device; and

a second field configured to record one or more content URL address information matched with the content identification information, and

wherein the content identification information includes all of

prefix information having a predetermined length,

a hash value obtained by processing the prefix information using a predetermined hash function, and

metadata of the received content.

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